

Environmental Policies

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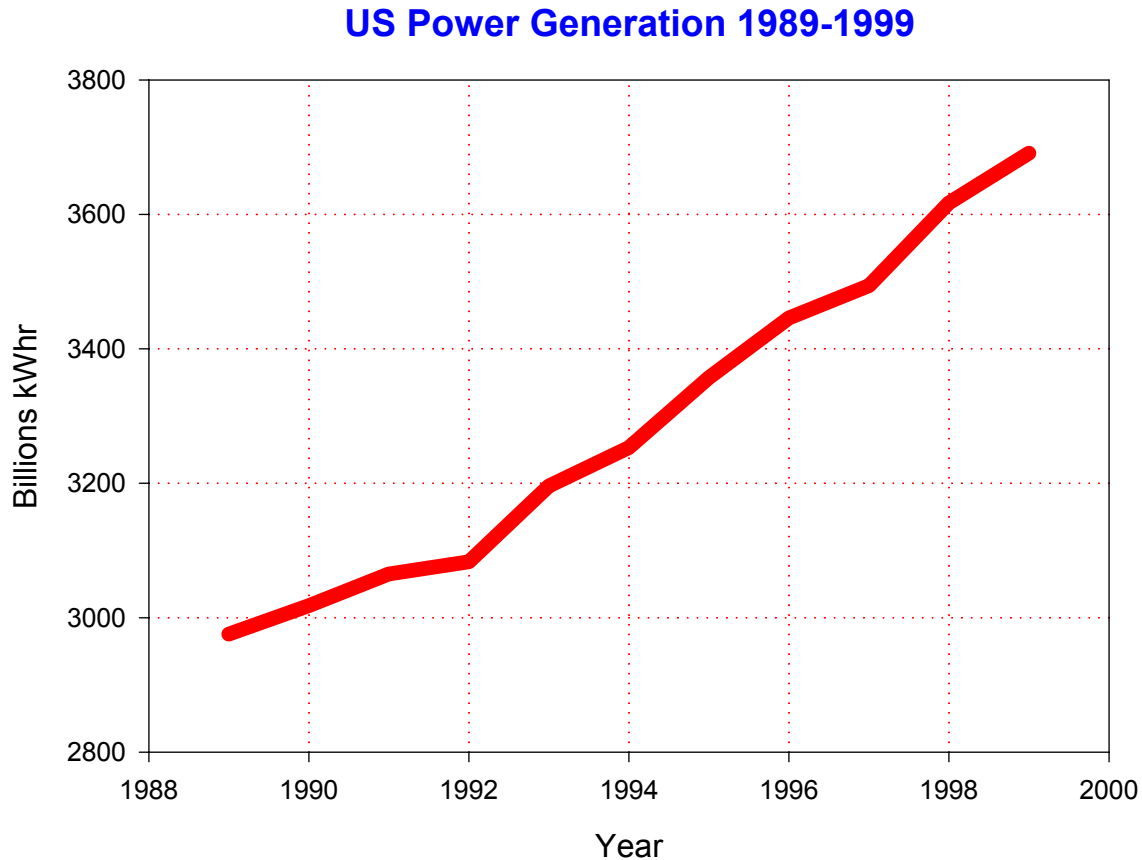
Overview

- **Gas turbine technology will continue to be play a critical role in US energy needs.**
- **Air quality improvements have been substantial, and sustainable development will continue.**
- **Improvements are needed in testing and analysis methods of emissions.**

Gas Turbine: Benefits

- **High degree of fuel flexibility**
 - **Gaseous fuels: Natural gas, furnace gases, landfill gases**
 - **Liquid fuels: No. 1, No. 2, residual fuel**
 - **Liquefied fuels: LPG and naphtha.**
- **Rapid production and manufacture**
 - **Build to demand.**
 - **Less space requirements.**

Why focus on Efficiency?

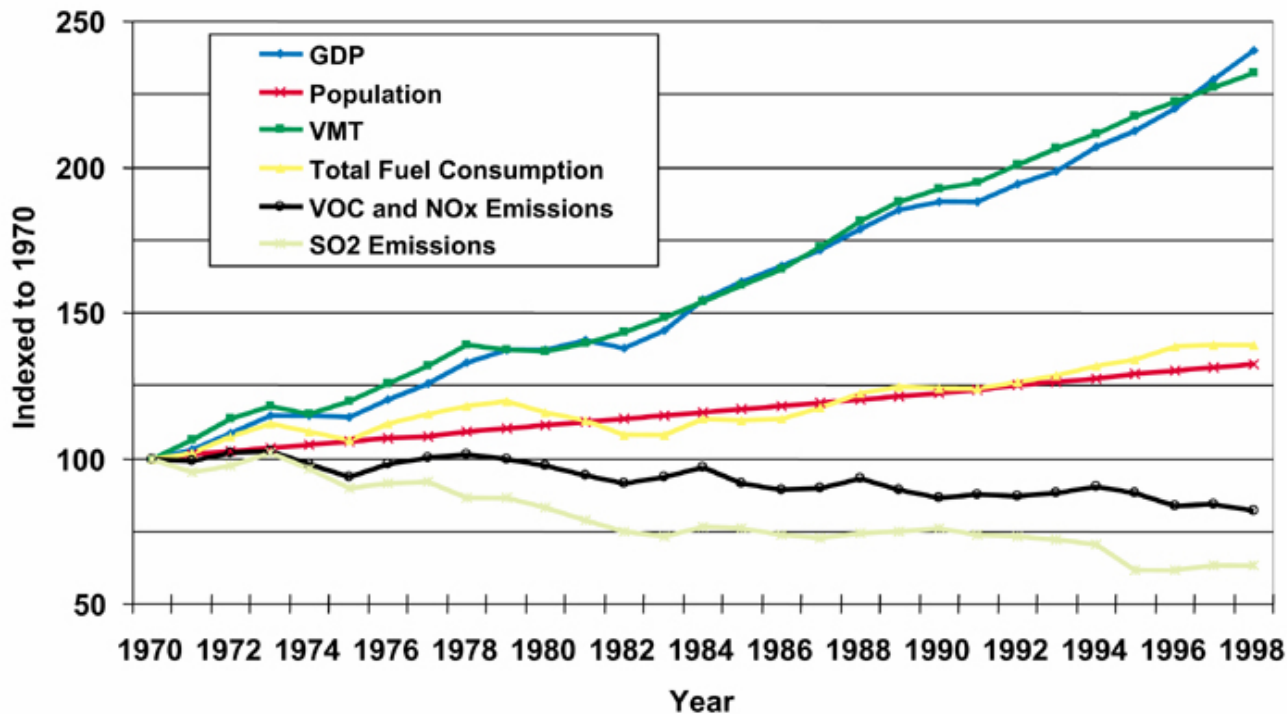


Air Quality Improvements through...

- **Technology implementation**
 - Combustor design
 - Catalytic reactors (mobile sources, SCR's, ox-cat's, etc)
 - ESP's (particulate control)
 - Flue Gas Desulfurization (SO₂)
- **Changes in fuel usage and fuel quality**
 - Switch from oil for illumination, expanded use of natural gas, Pb removal
- **Enhanced energy efficiency**

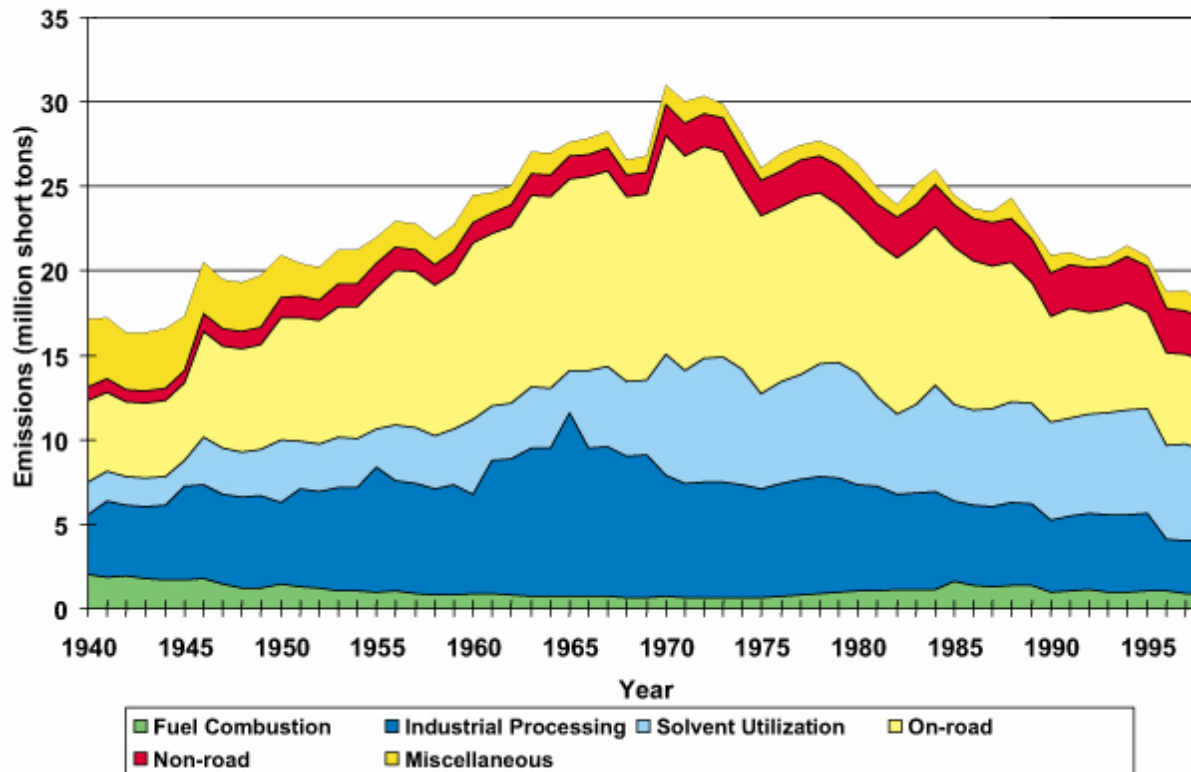
How have things changed since 1970 CAA?

Figure 3-1. Trend in Gross Domestic Product, Population, Vehicle Miles Traveled, Total Fuel Consumption, combined VOLATILE ORGANIC COMPOUND and NITROGEN OXIDES Emissions, and SULFUR DIOXIDE Emissions, 1970 to 1998



VOC Emissions

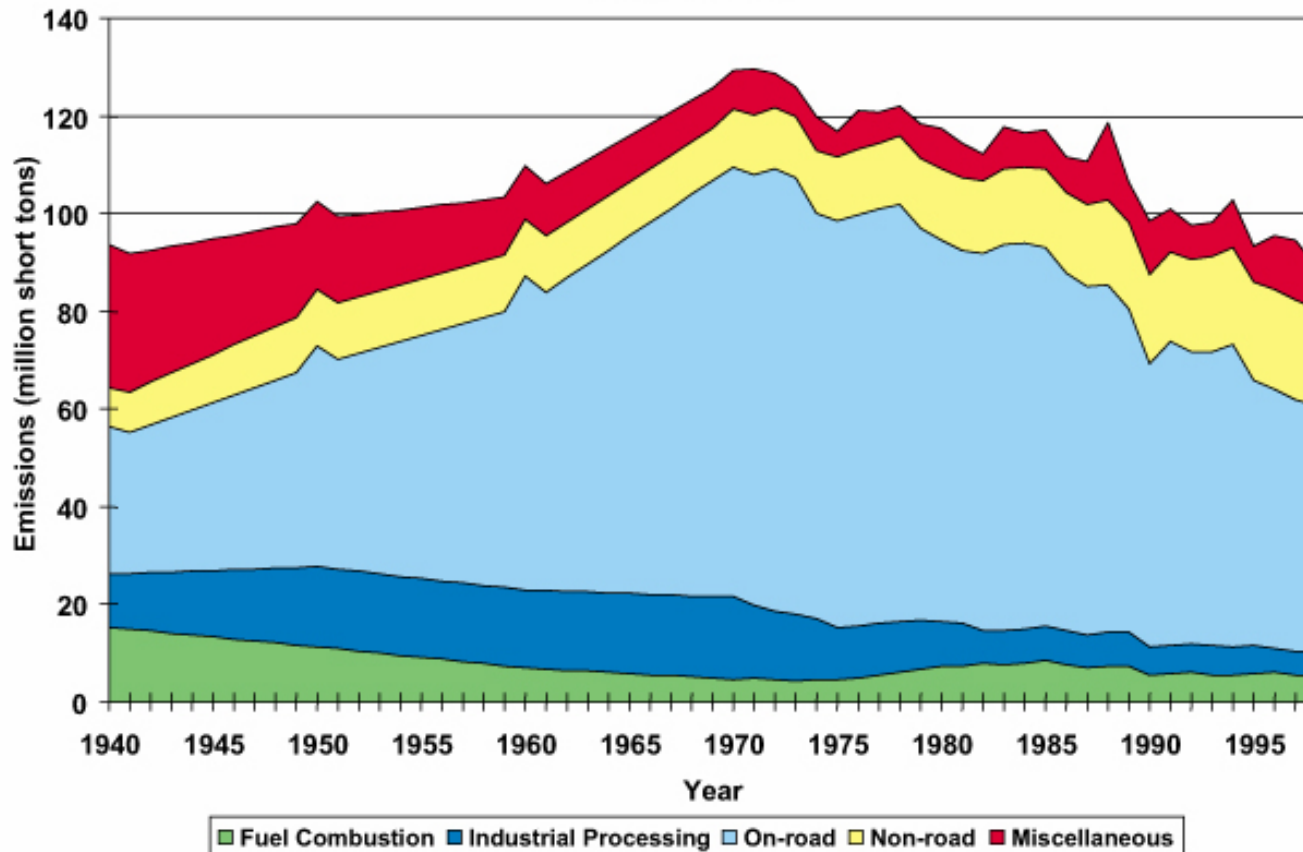
**Figure 3-4. Trend in VOLATILE ORGANIC COMPOUND
Emissions, 1940 to 1998**



Note: some fluctuations in the years before 1970 are the result of different methodologies

Carbon Monoxide Emissions

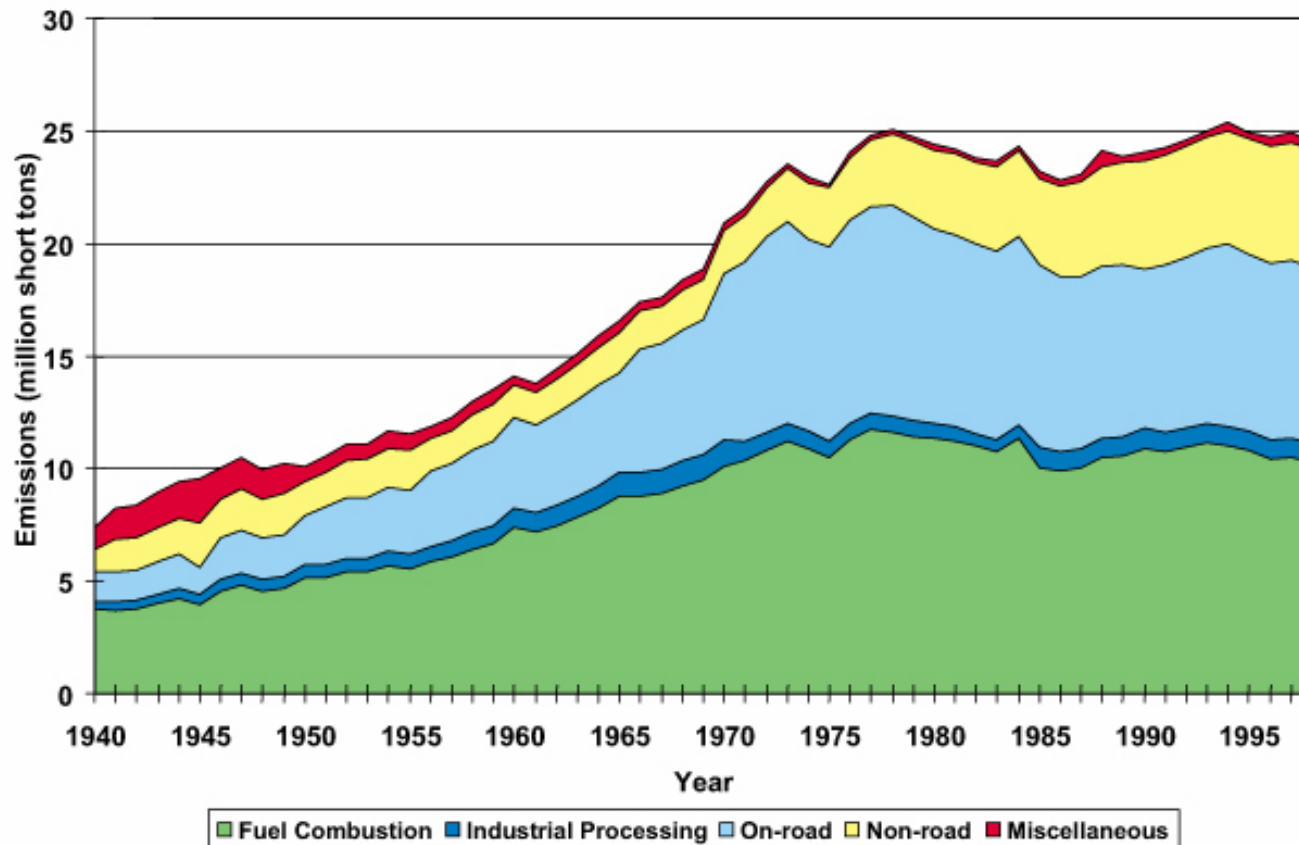
**Figure 3-2. Trend in CARBON MONOXIDE Emissions,
1940 to 1998**



Note: Some fluctuations in the years before 1970 are the result of different methodologies

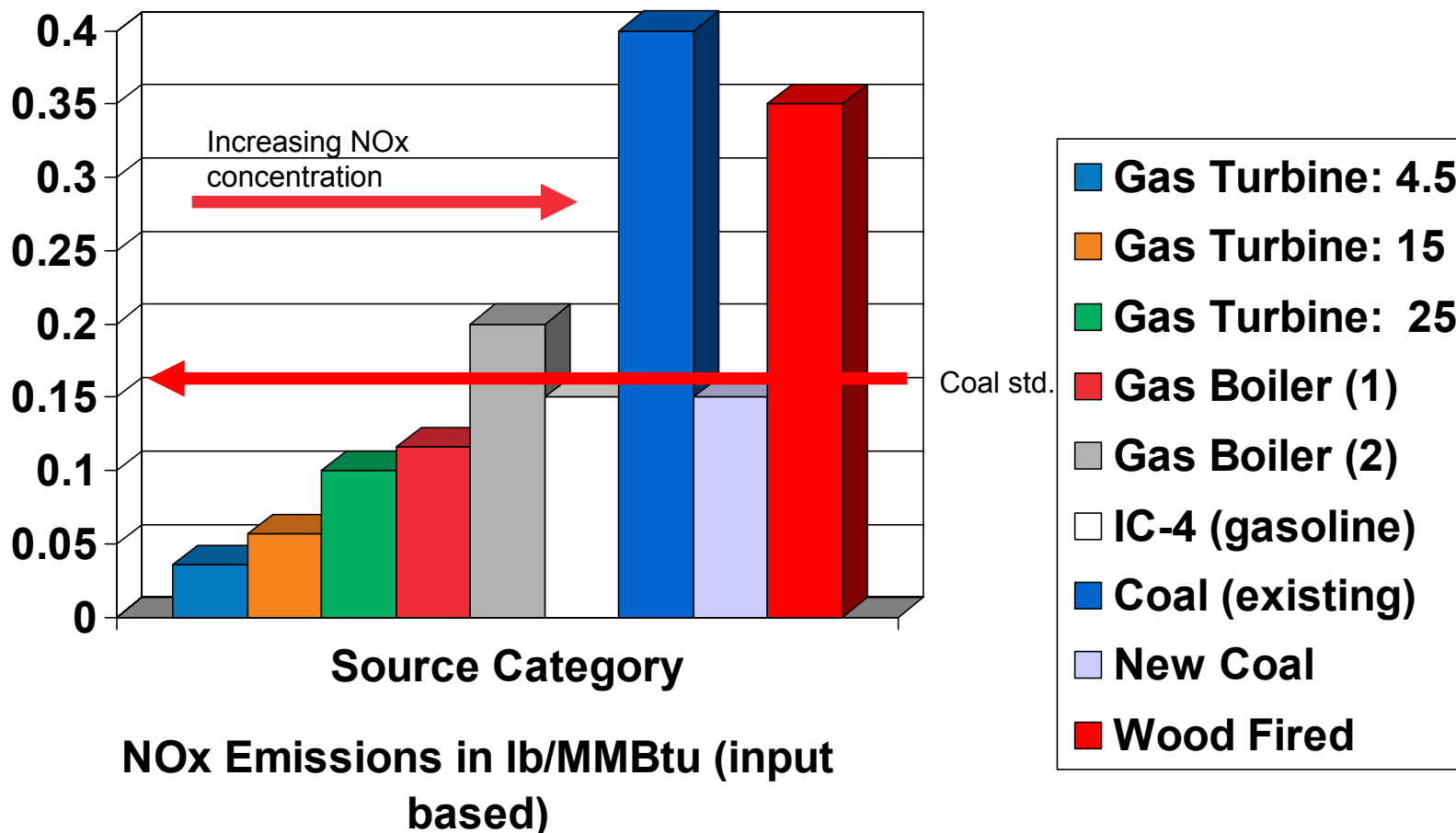
NO_x Emission Trends

**Figure 3-3. Trend in NITROGEN OXIDE Emissions,
1940 to 1998**



Note: Some fluctuations in the years before 1970 are the result of different methodologies

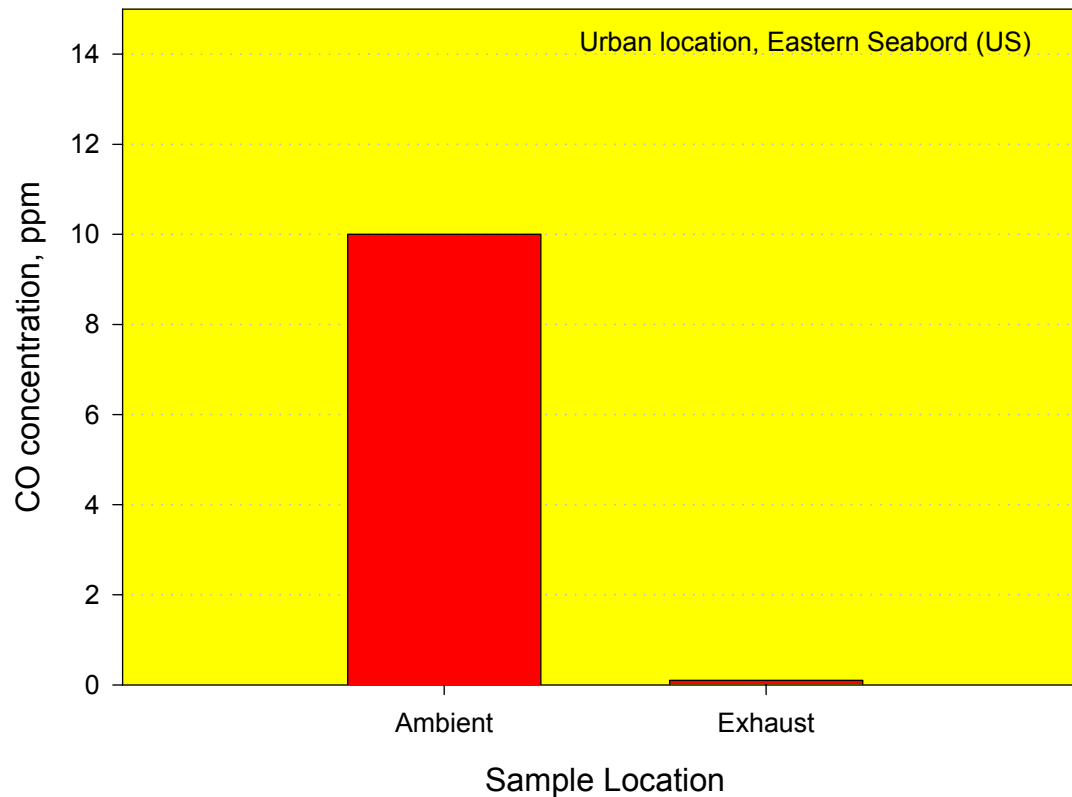
Emissions from Various NO_x Sources



Gas Turbine Challenges

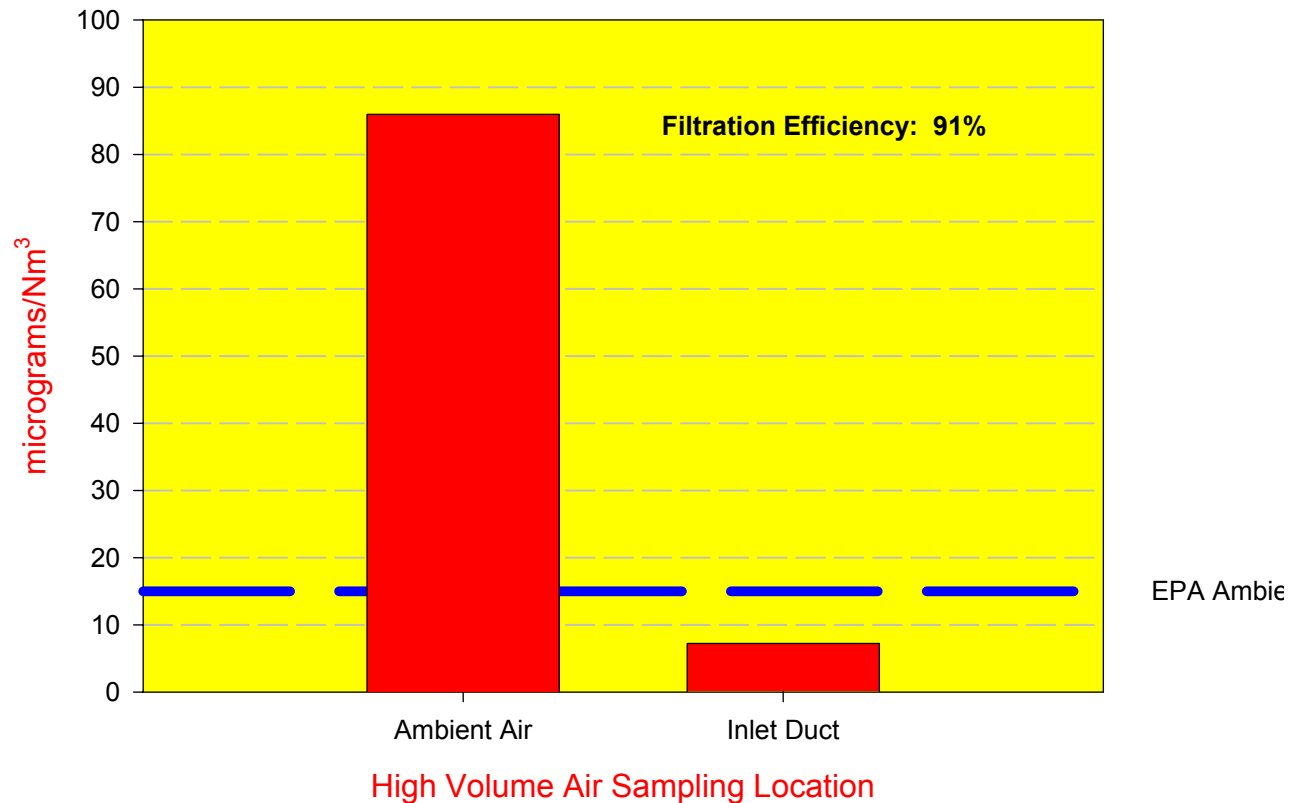
- **Existing regulations do not account for environmental benefits.**
 - Exhaust concentrations may be less than the inlet/ambient levels.
- **Current measurement methods are limited**
 - At single-digit levels, measurement can be difficult and unreliable.
 - Some components under consideration are extremely difficult to accurately measure (formaldehyde and ammonia)

Impact on Ambient CO



Impact on Ambient Particulates

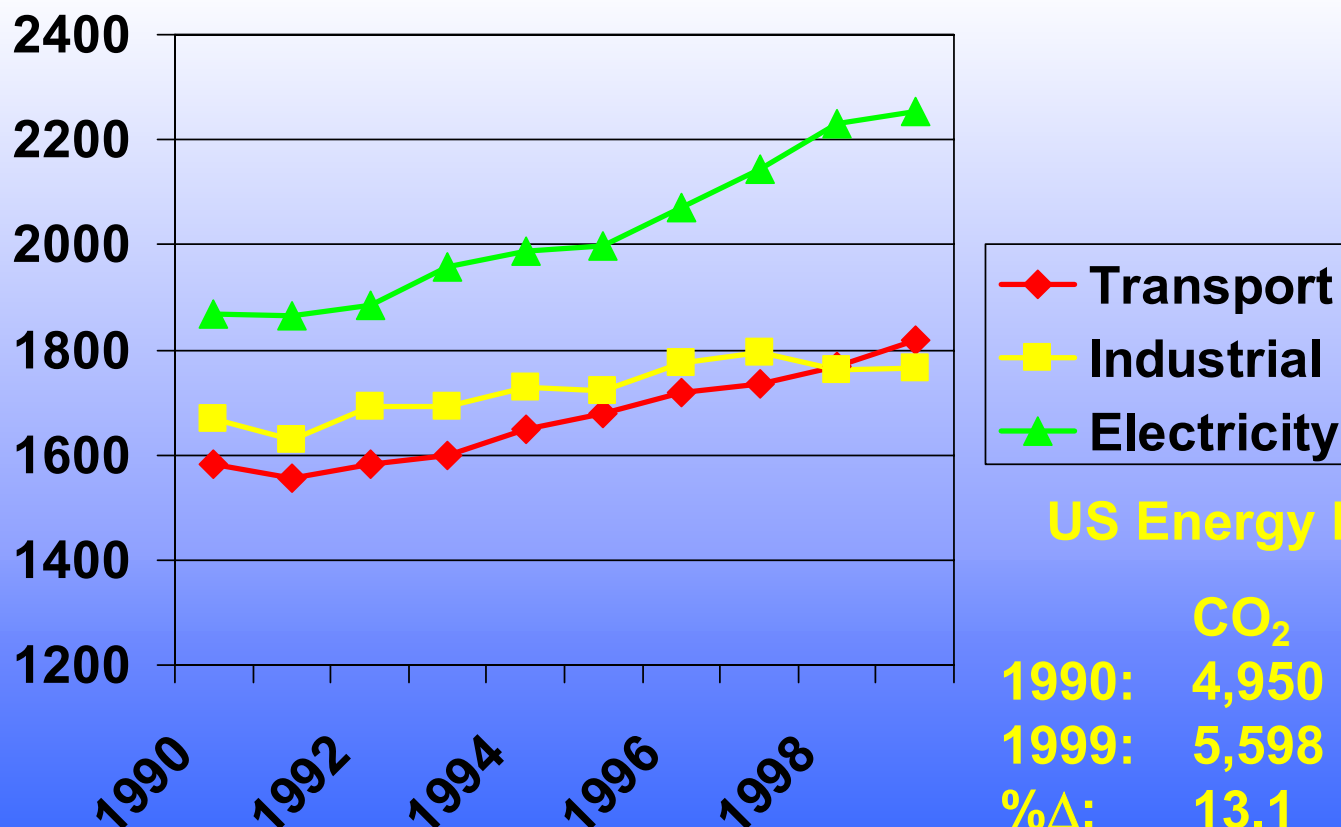
Gas Turbine Filtration System (Typical)



Driving forces for regulation

- **Climate Change**
 - **CO₂, CH₄, etc.**
- **Health related issues**
- **Regional Haze**
- **Hazardous Air Pollutants**
- **Acid Rain**
- **Protection of Ozone Layer**

Climate Change: Greenhouse Gases (US)



Million Metric Tons CO₂ (EIA, Oct. 2000)

www.eia.doe.gov/oiaf/ggrpt/index.html

US Energy Balance

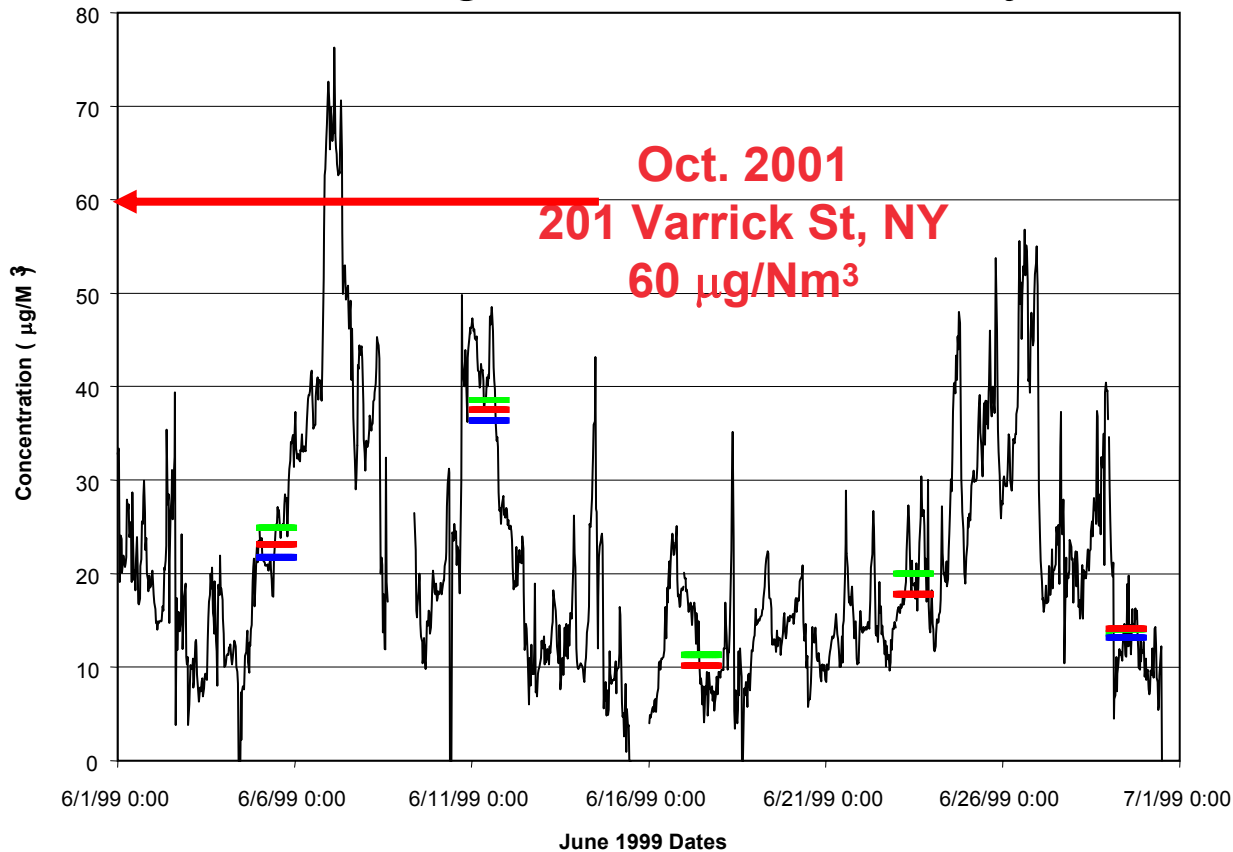
	CO ₂	Quads
1990:	4,950	71.95
1999:	5,598	81.56
%Δ:	13.1	13.4

Improvement in η to
return to 1990 values

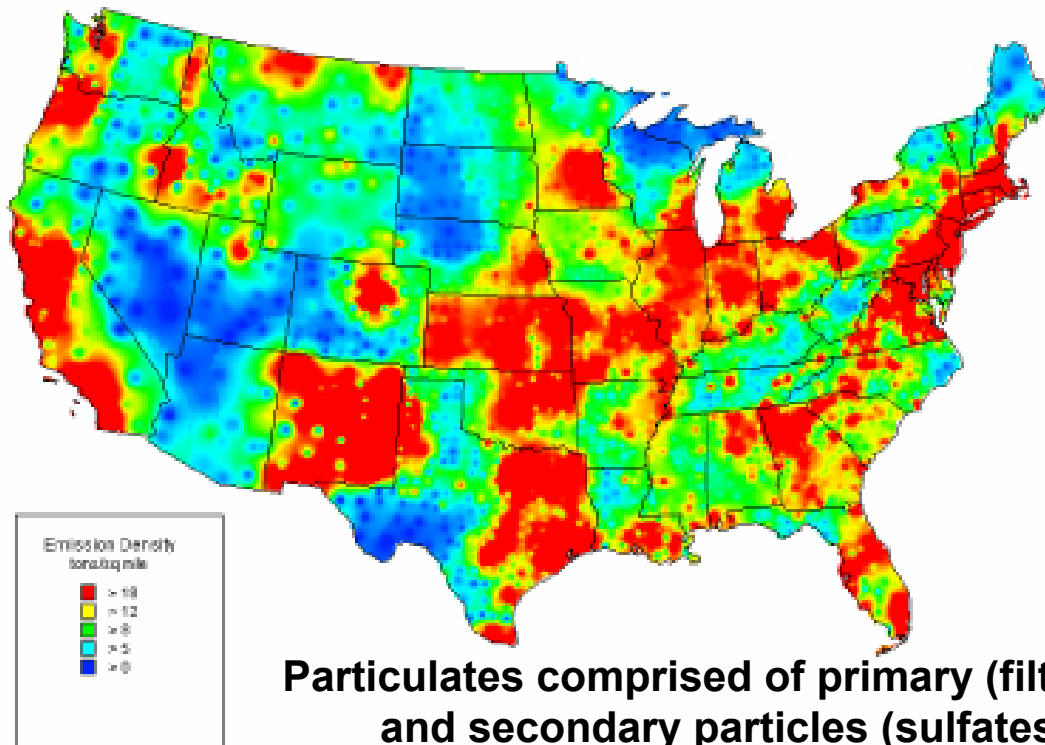
33% \Rightarrow 37.3%

Regional Haze: Particulates

Ambient Monitoring: Ohio River Valley



Particulate Emissions by County (PM₁₀)

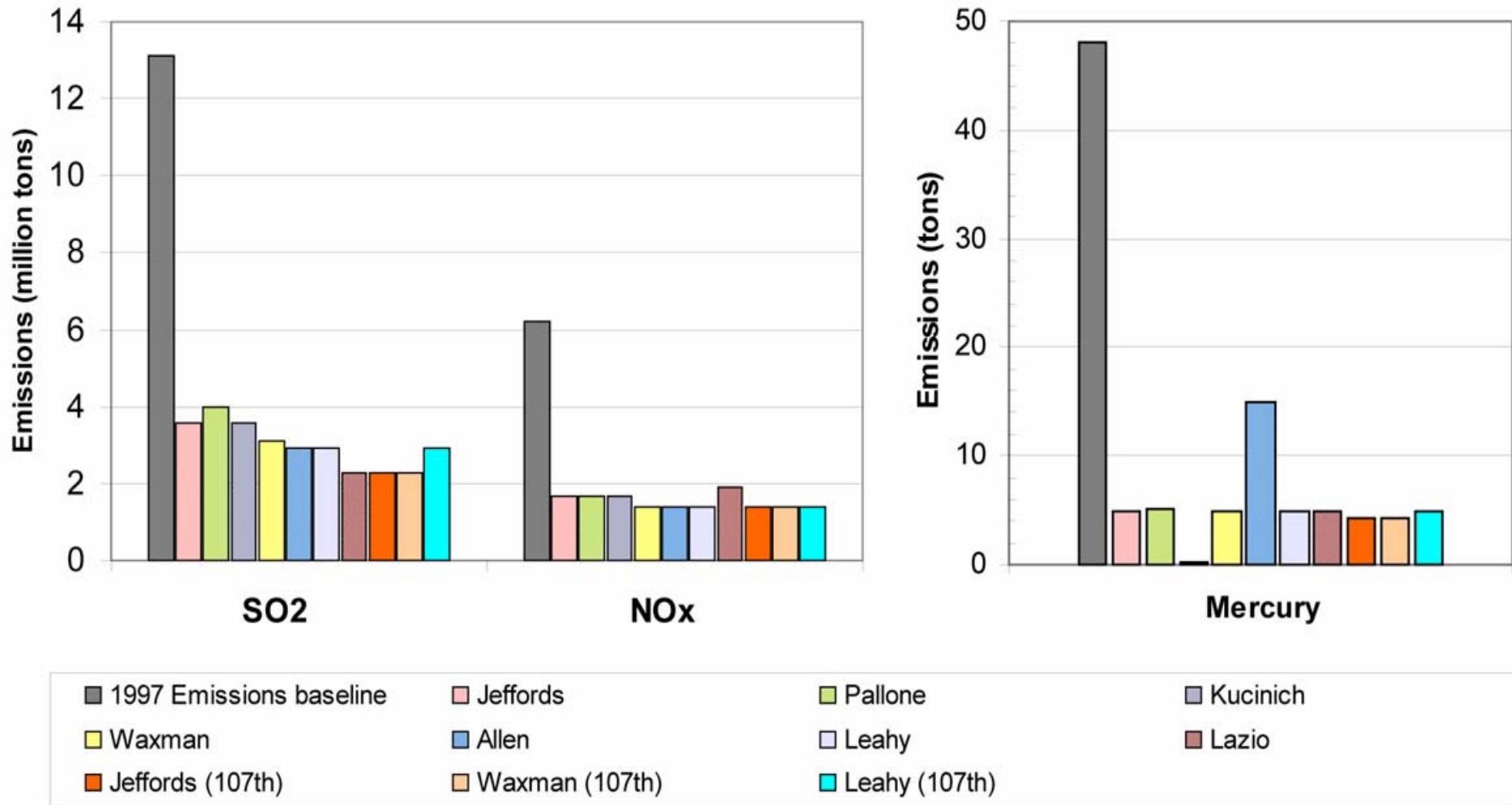


Clean Power Act

- **S. 556**
 - **Multi-pollutant bill**
 - **Includes CO₂ (climate change)**
- **HR 1335**
 - **SO₂: 3 lb/MW hr**
 - **NO_x: 1.5 lb/MW hr**
 - **Hg: 90% Reduction**
 - **CO₂: 1.914 Billion (down from 2.2 in 1998)**

Congressional multi-pollutant control levels

Levels proposed in the 106th and 107th Congress

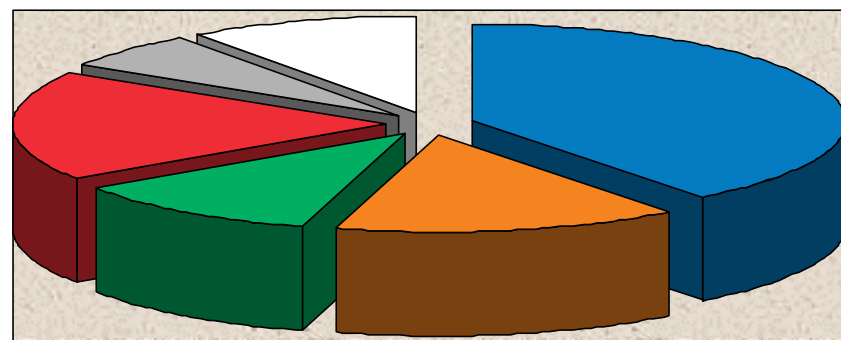


Graphic does not include a bill introduced by Sen. Allen in the 107th Congress

Formaldehyde Emissions

- **Classed as carcinogen**
 - California classifies it as a very weak carcinogen
- **MACT 112: Regulation of Hazardous Materials**
 - Including CH₂O
- **Major Source**
 - 10 tpy of HAP
 - 25 tpy of Aggregate

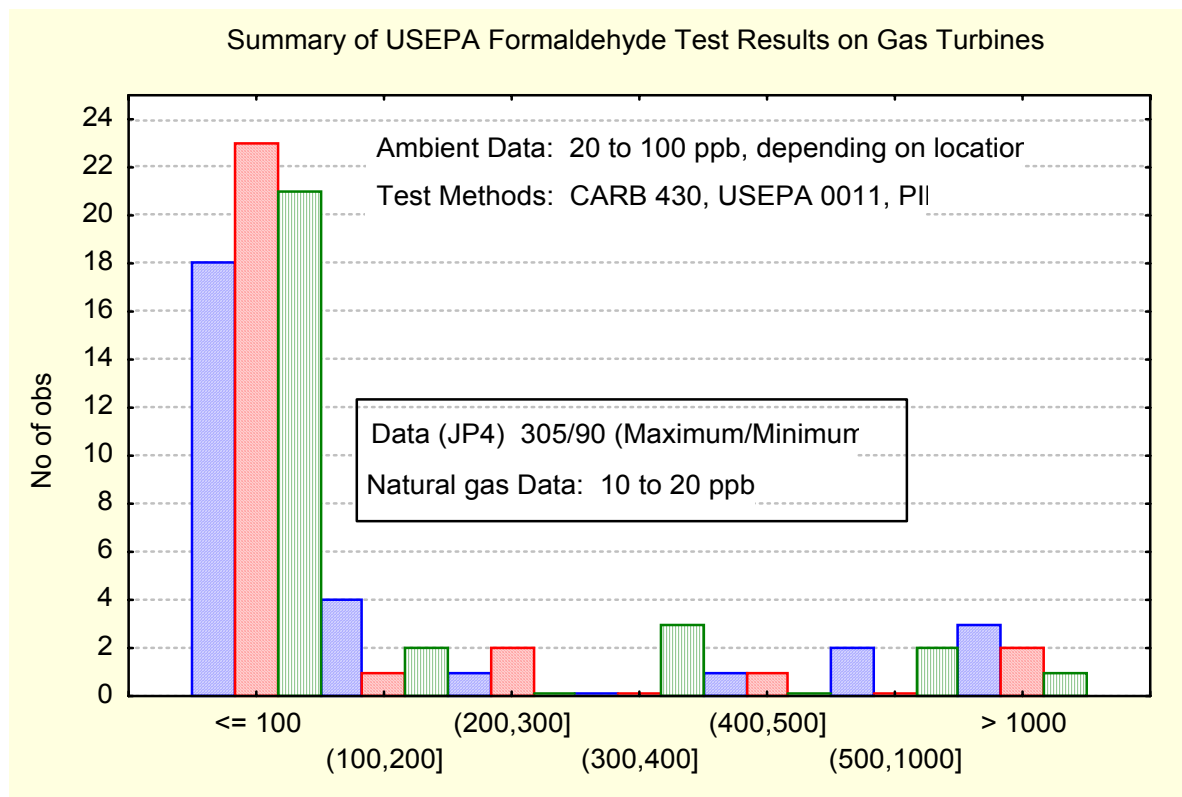
Risk Contribution Factors



- Formaldehyde
- Carbon-Tet
- Gas-Vapors
- Steel/Coke
- Combustion
- Other

Possible Proposed Regulations

- **Proposed EPA Standard**
 - **25 ppb**
 - **90% reduction of test averages.**
 - **Ambient levels could exceed these amounts.**



Challenges....

- **Technology selection.**
 - What is BACT?
 - What technologies work together?
- **Compliance Monitoring**
 - Batch verification
 - Continuous Monitoring
- **Determining the real impact on the environment.**
 - It's not the permit.....

Technology Selection

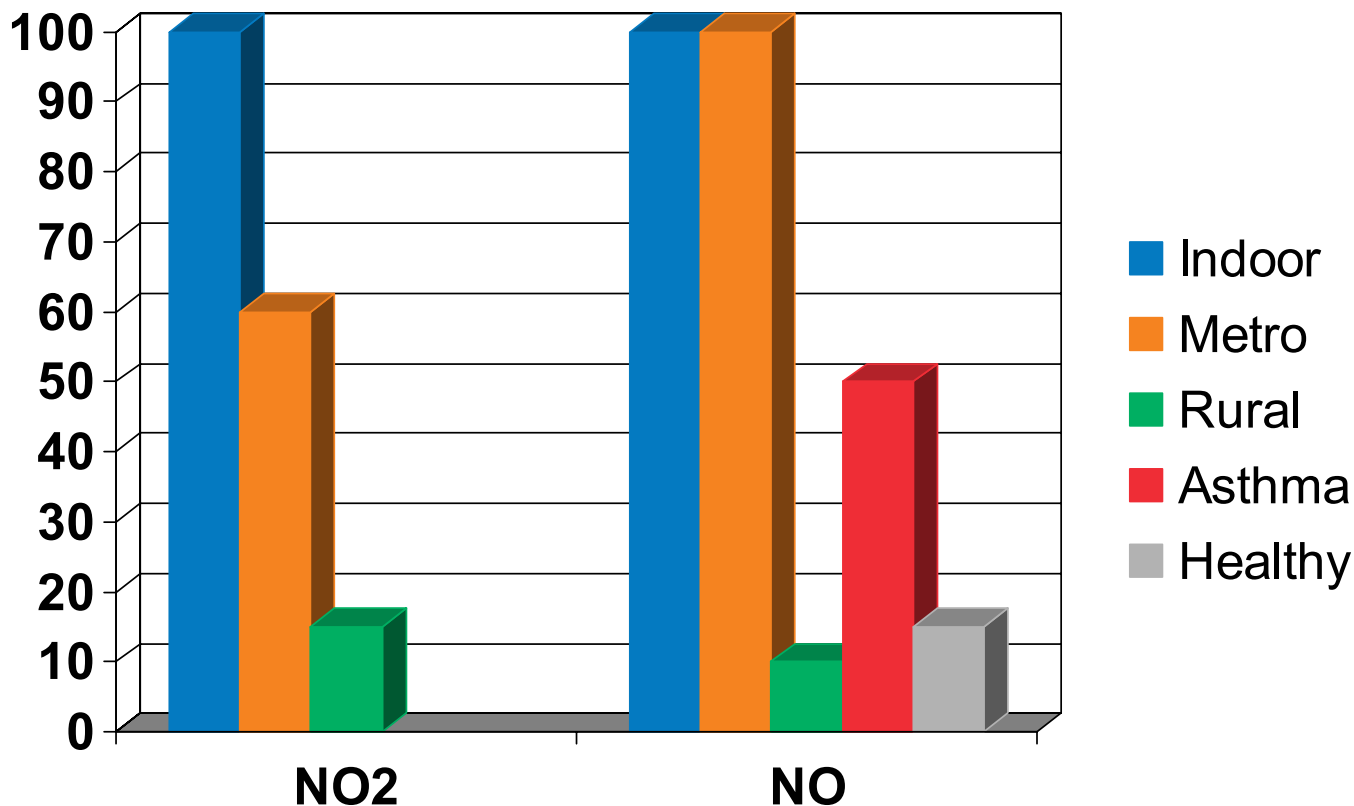
- **For Gas Turbines, DLN should be Best Available Control Technology**
 - Not all gas turbines achieve same NO_x levels.
- **Technology “Stacking”**
 - Not all combinations of control technology can be added together
- **Consider that the gas turbine is not a “source” for all priority pollutants. In some cases it may be a “sink”.**

Environmental Compliance

- **CEM systems at limit for monitoring ultra-low level emissions**
 - **NO_x emissions are problematic at levels below 4 ppm**
 - **NH₃ emissions are extremely difficult to measure at any level due to the reactivity of the gas and high solubility**
 - **Particulates: no approved continuous method**
 - **Particulate batch tests unreliable.**

Measuring Low NO_x

2 ppm exhaust NO_x measured with a dilution system requires 100 ppb accuracy



Environmental Monitoring

- **Verification is costly, time consuming, and potentially unreliable.**
 - **Particulate emissions often below detection limits with gas-based fuels.**
 - **1 mg/Nm³ is probable limit for RM.**
 - **RATA is inaccurate in ultra-clean exhaust gas.**
 - **HAP's testing method (CARB-430) may not be reliable.**

Summary

- **Air quality improvements have been significant, but issues are shifting.**
- **Emissions should be assessed on a *net* basis to determine environmental impact.**
- **Output based standards. Easier to compare technology choices.**
- **BACT for gas turbines is not a specific emission level.**

Summary

- **New instrumentation technology needed for low emission measurement.**
 - **NO_x, ammonia, particulates**
- **Methods and instrumentation for HAP's.**
 - **Is formaldehyde a significant emission factor, or is it an artifact of the testing?**
- **Remove monitoring for some species on natural gas:**
 - **Lead, particulates (PM/PM₁₀/PM_{2.5}) , formaldehyde, acetaldehyde.**

Summary

- **Access existing talent pool to develop and review new measurement approaches.**
 - EPA, DOE, Corporate, Professional Societies
- **Avoid the “Guidelines” pitfall.....**
 - “Guidelines” often evolve into “policy”
- **Speed up the process.....**
 - Certification of engines based on production standards